EXHIBIT A



Ciena's Technology Tutorial

4:17-cv-05920-JSW

Dr. Richard Gitlin

July 9, 2020

Richard Gitlin, Sc. D. Case 4:17-cv-05920-JSW Document 112-1 Filed 07/08/20 Page 3 of 31

50+ years of communications and networking leadership

Education:

Doctorate in Engineering Science from Columbia in 1969

Experience:

- 30+ years at Bell Labs (SVP at retirement)
- Visiting Professor at Columbia University
- CTO Silicon Valley Startup
- Distinguished University Professor at University of South Florida

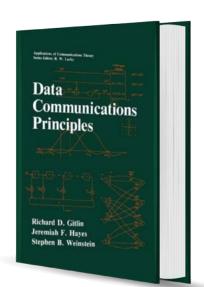
Awards and Accomplishments:

- National Academy of Engineering
- Charter Fellow, National Academy of Inventors
- IEEE Fellow, Bell Labs Fellow
- Florida Inventors Hall of Fame
- Data communications textbook, 170 papers, 71 U.S. Patents

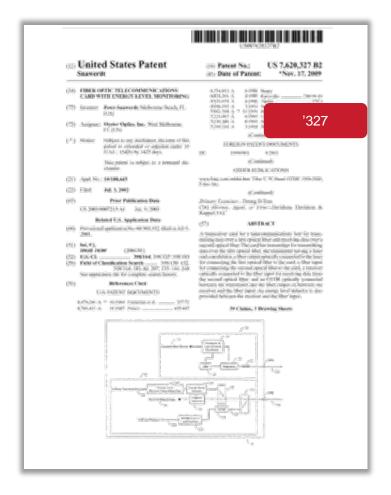
Major Innovations:

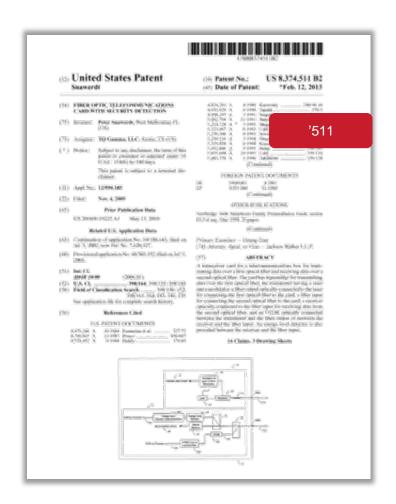
- Co-inventor of Digital Subscriber Line (DSL) technology
- Electro-optical receiver processing
- Smart antenna, MIMO wireless technology

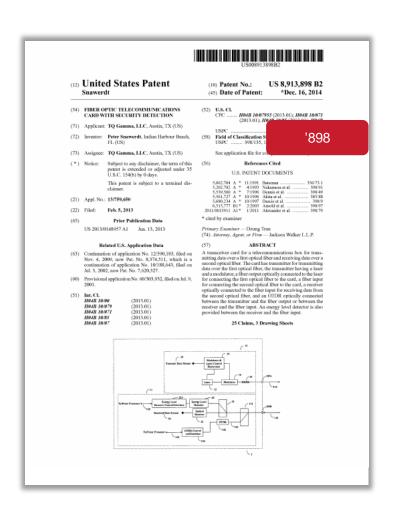




Asserted Patents: U.S. Patent Nos. 7,620,327; 8,374,511; 8,913,898 FIBER OPTIC TELECOMMUNICATIONS CARD WITH ENERGY LEVEL MONITORING





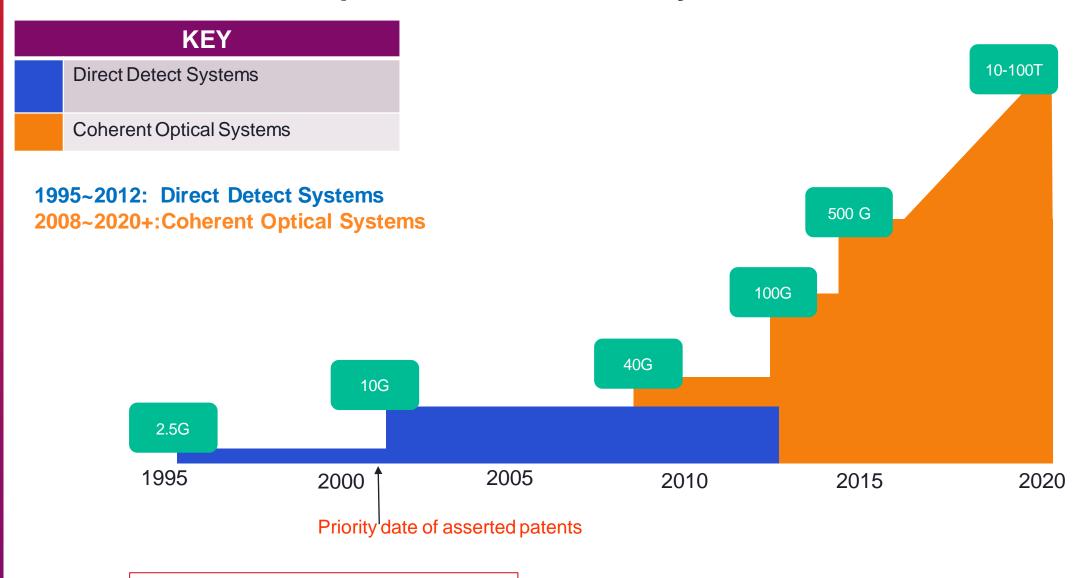


According to the common specification in the Asserted Patents, existing "systems have the disadvantage that the optical fiber can be easily tapped and are not secure," and the Asserted Patents describe the invention as "providing secure optical data transmission over optical fiber" by using tapping detection capabilities.

OVERVIEW OF OPTICAL COMMUNICATION SYSTEMS

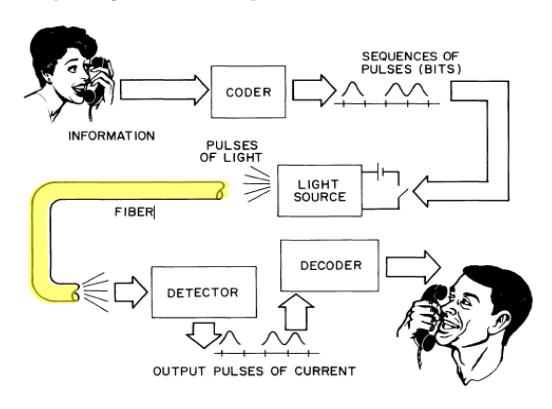


Evolution of Fiber Optic Communication Systems



G denotes gigabits (billion) per second

Exemplary Fiber Optics Voice Communications System



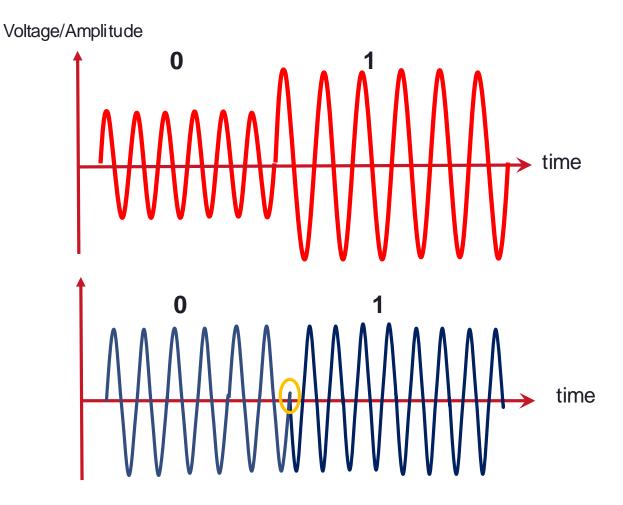
- Voice is digitized to binary data by the coder.
- The speech coder output bits that modulate the intensity of the optical light source (on/off).
- The modulated signal is transmitted over the fiber.
- At the receiver the intensity of the optical pulses is detected by a photodetector.
- The electrical output signal is applied to the speech decoder.

Optical Signal Basics - Woodulation of an Optical Signal

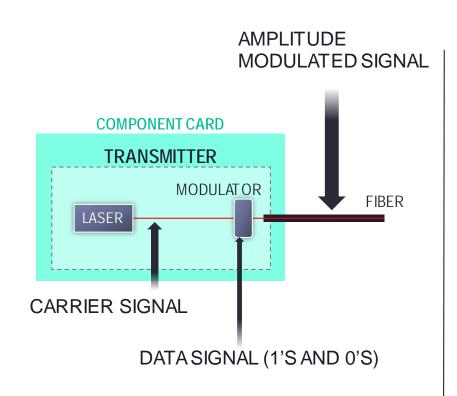
Light travels in waves of very high frequencies. In order to transmit data over long distances using optical communications we manipulate, or <u>modulate</u>, carrier lightwaves to transport the data.

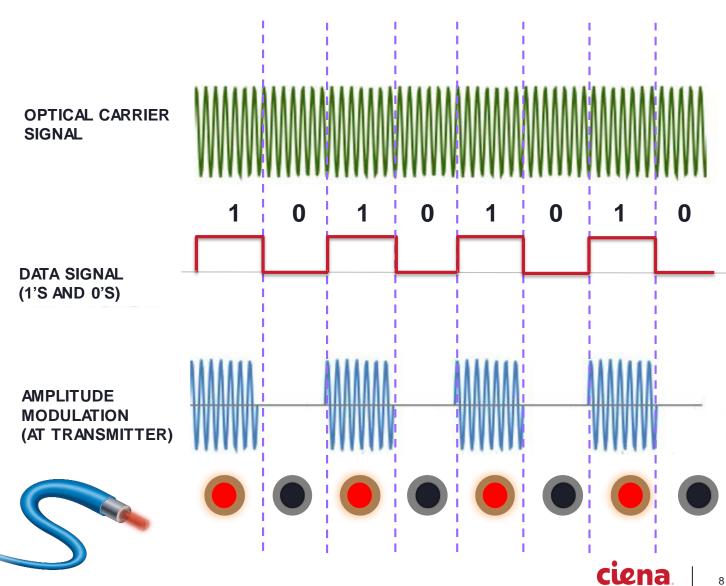
Amplitude Modulation (AM)

Phase Modulation (PM)

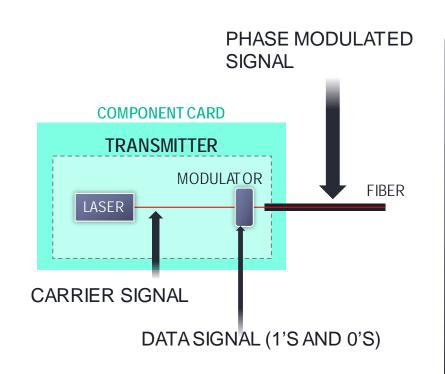


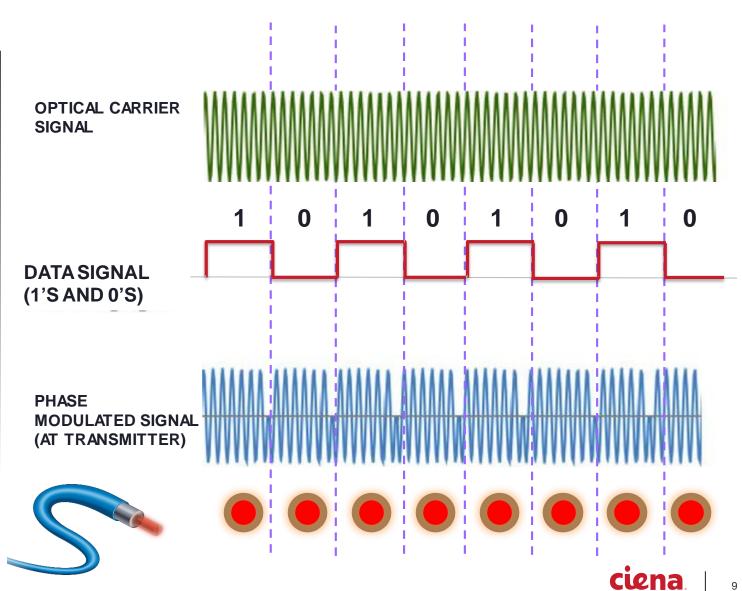
Amplitude Modulated (AM) Optical Signal





Phase Modulated (PM) Optical Signal



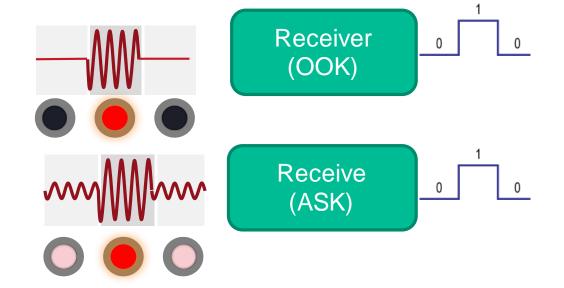


Receiver Processing

Amplitude Modulated Signals

The receiver determines if a zero or a one is sent by looking at the *intensity* of the light.

The *intensity* is synonymous with the *brightness* of the light and is related to the light energy.



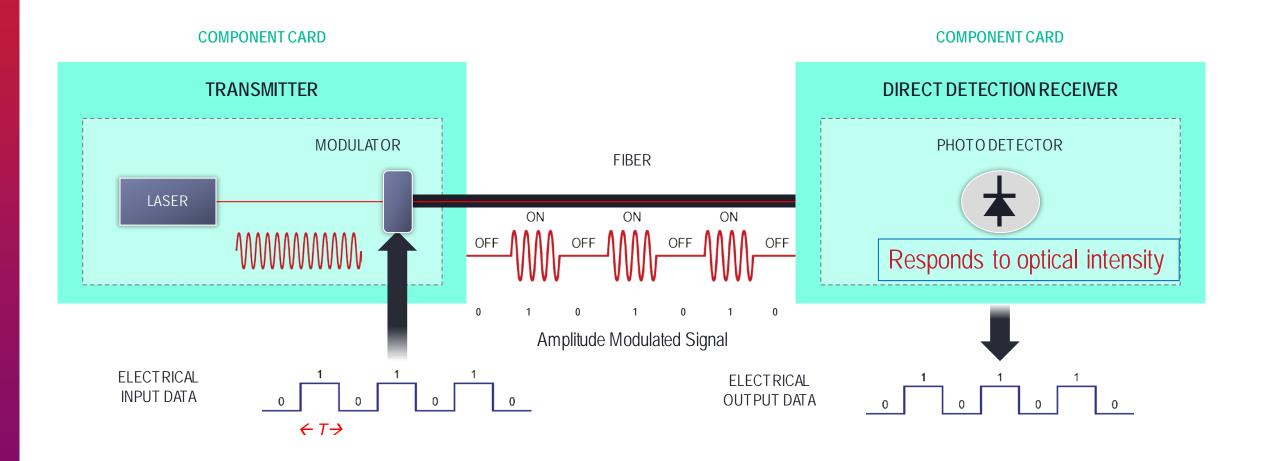
Phase Modulated Signals

The receiver determines if a zero or a one is sent by looking at the *phase* of the light.

For this presentation, it will be assumed, as the patents do, that the *brightness or amplitude* of the received phase modulated signal remains *constant*.



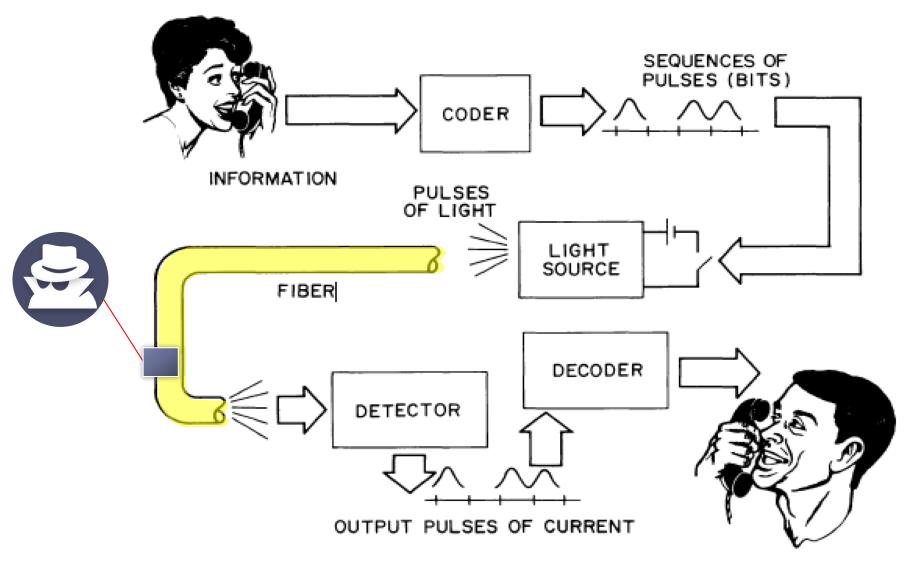
Early Fiber Optic Transmission Systems Used Amplitude Modulation and Direct Detection



SYSTEM SECURITY AS PRESENTED IN PATENTS



Fiber Optic Systems Were Susceptible to Unwanted Tapping



The patents address a concern that a network intruder could tap the optical fiber without easily being detected

Security of Fiber Optic Cables

US 8,913,898 B2

FIBER OPTIC TELECOMMUNICATIONS CARD WITH SECURITY DETECTION

CROSS REFERENCE TO BEE ATED APPLICATION.

The present gutent application is a continuation of U.S. potent application Ser. No. 12/540.185, filed Nov. 4, 2007; which is a continuation of U.S. garent application Ser. No. 10:189.543 (nov. 175. Pm. No. 7,620.327), filed bid. 3, 2002. which chios prints to U.S. Psychianal Patest Application Ser. No. 60/305.032, filed Jul. 9, 2001; the entirery of which are all benefity incorporated by reterence-

BACKUROUND OF THE INVENTION.

J. Field of the Invantion

The present invention relates generally to telecommunications and more particularly to insumition and receivers for liber-optic networks:

2. Rickground Information

In current fiber-ontic networks, an electronic data stream is fed to an original other, multipleson, which is plus spilled for box" in the industry. black stabledow man on a specific amplitude modulation elecuit for the laser typically are located on a card, which fits into the bex. The laser amplitude modulator typically pulses or afters the loser sustantascence. an complicate anotherized optical signal representative of the electronic data stream. The laser amplitude modulator and later than define a transmitter for transmitting the optical signal over us ordered filter. A receiver for the amplitudemorbilated optical signals of the optical data typically includes a phr-ordinale to creaven the optical eigensts back into the electronic data stream. Both the imagnifier and the receiver repically are located on the backgrame of a simple eard, which is replaceable should a component fild-

The cord typically also contains a connector for receiving at least one optical liber, for axample a displex SF connector. gard, the faceplate being perpendicular to the backplane.

The rending of the neighbode-mechanical optical data sign raise using the photodiodeson the gard is straightforward: the optical square cetter produce as electric output at the placks diode or they do not. As a reads, an output electronic data is stream of increasional cone in presented.

The electronics for the amplitude insolubation of the baser and for the receiving of the optical data on the and thus is: relatively sample. All that is required is a pulsing circuit for publing the later, as a cheer function of the input data and a no letter in the optical titler or near the arbanyof relative to the photodiode for the receiver.

United by a supplication and district respects have the three beauty tope that the liber can be easily topped and are not seems.

#1.5. Usa. No. 5:455:579 gargarhito-shipfing apassar-illar optic communicational systems based on the principles of a 70 Suggest interferometer: A data transmitter top phase modula: nor for modulating counter-propagating light Sciens was by is receiver round a foop. The receiver includes a light source, a beamplifter for splitting fight from the hight source into counter-propagating light beams and for according the phase. modulated high beams and accompanies over his Subsides. 5222/967 describes a similar Sagnac interferometer/based society operating over a single optical liber.

The Sugrac interferencer-based systems described in to stated over a loop, whether back and first in a single-liber. or own in longitudity from differ. As a world, of the fink

bodges for the single liber must be doubled, reducing the data carrying capacity for a single filter, or clue a foogod littles with significant and expensive extra length of an least twice that of ad how retimenest adt growted best ad form redd algories. receiver. Moreover, the receiver contains the light source, as opposed to the current installed have where the transmitter Sustification source.

The Suppose interferomater has advantaged that are expensive to boild and operate, and the net work garnisularly well with oxioing enthiplexors or card format-

Several companies currently provide OFBR topsical timedomain reflectionsters) which can monitor an orbical liber and determine if the presence of and focution of a break in the ther. Such communies include Youts Communication Co. 15 with the MW Series Mini-CVERR and CVERR modelles from Tekronix Communications

These eletations however are expensive and must be applied to the liber away from the box.

U.S. Phi. No. 5,7733539 diseloses details of O'DDR teck. 26 inology and is barely incorporated by reference border.

SEMMARY OF THE PRESENT INVENTION

An object of the present invention is its provide a transtransmission products, for example, SONTY. A baser and on its convert and for providing secure optical data transmission ever optical liber. Norther dremote or additional object of the present invention is its pay ide for explacement of whiting conde with a transaction and permitting EEPER and rapping detection copolities

The present an entire provides a true-scene card for transmitting data over a liest optical liber and receiving data over a second optical tibes the cord having a transmitter for transinsiting data over the first optical liber half is processer for receiving data from the second optical tiber, and an OFDR connected optically to the second optical filter optimizes or from the revener. Preferably, the OFDR aperates at a wavelength attack of digitizens often into wave length world for claim instruments. sant and eventured in thoughted eiems via a waveforath shirking multiplexed coupler. By opening the HHH SE at a The connectors assembly are located on a thoughout of the se wavelength defence than the wavelength used by distribute mission, the OFFIR may be allowed to continuously operate without disruption of the data entitle

Profesible, anomeny, level detector is also precided on the eard. The energy level detector is preferably optically connected to the second liber between the OTDR and the receiver.

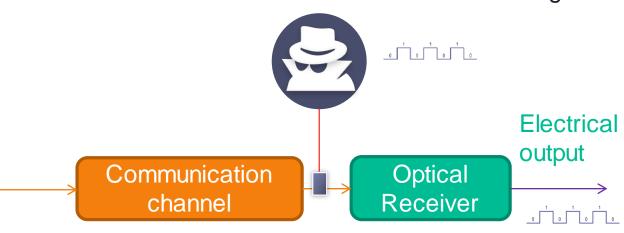
The OFOR preferably is mountered by an embedded processor weaking this from This processor analysis all a WHOR output data its determine of the characteristics of the optical Other two states blosse ichangeal inelative, but a inelemented charakters reference OFIRE characteristic, then a deprodution of the reprised liber reviews, while breast landicate a filter breach or a Ober up: can'be logged along the perinten of the degradation symmetrishing with location of the FFHR. The indication of degradation of the liber system may provide an alumn signal. for grampleon electronic signal sent to a nempels operations. center to indicate the interview diagnostrious of the afternoveterry along with the approximate location of the degradation point, is fightier the cubide of the boxies a sounderniting plants. Alientatively, the OTDR enigns may be connected to a display model vision chorical connection on the earl for displaying humany operator, or transferred the the transprisor to be analyzed at the network operations residen.

The transceiver card of the present invention preferably has these parents have the disadvantage that they require the hight of other spens long this range of the operation that are some other wish standard opsical multiplexers persists the example, two to exactly kelemeters or tensor one funded Kalemeters. The

Existing amplitude modulated systems have the disadvantage that the fiber can be easily tapped and are not secure.

'898 patent at 1:52-53

Intruder sees an attenuated signal



How is optical tapping performed?

'898 patent at 1:52-53



What Is An Optical Tap?

Case 2:16-cv-01302-JRG Document 165-4 Filed 10/03/17 Page 2 of 21 PageID #: 2119



OYSTER OPTICS, Inc.

Securing Fiber Optic Communications against Optical Tapping Methods

Optical tapping devices placed in public and private optical networks today allow unfettered access to all communications and information transiting any fiber segment. Available legally and inexpensively from numerous manufacturers worldwide, optical taps are standard network maintenance equipment that are in use daily. When used nefariously, optical taps provide an excellent method of intercepting voice and data communications with virtually no chance of being detected. Intruders are therefore newarded with a bounty of relevant information while subject to a very low risk of being caught. Optical network equipment manufacturers do not currently incorporate adequate protection and detection technologies in their platforms to monitor such network breaches in real-time. Network operators thus cannot safeguard the optical signals on their networks and therefore cannot prevent the extraction of sensitive data and communications. Government networks, while assuredly more secure, are also vulnerable to certain types of advanced passive and active tapping methods. This background paper serves to provide an overview of the vulnerabilities of today's modern optical networks; describe methods of addressing such issues; and introduce Oyster Optics' patented optical security, monitoring, intrusion detection and breach localization solutions.

INTRODUCTION

Fiber optic telecommunications systems make up the backbone of all modern communications networks. Whether voice, data, video, fax, wireless, email, TV or otherwise, over 180 million miles of fiber optic cables worldwide transport the everince assing majority of our diverse information and communications. Modern economies and societies rely on the availability, confidentiality and integrity of critical fiber optic network infrastructures to function properly and efficiently.

With the initial introduction of fiber optic telecommunications systems came the belief that fiber-based transmissions are inherently secure. It has since been proven that not only are fiber optic systems simple to tap, but in many respects they are simpler to tap than their copper-based predecessors. Furthermore, tapped optical networks divulge much greater pertinent information in a more orderly and digitized manner. In fact, many fiber optic taps are standard network maintenance equipment used daily by carriers worldwide. Used illicitly,

however, such devices allow the extraction of all voice and data communications in the fiber plant with little or no chance of desection.

This is achieved because the light within the cable contains all the information in the transmitted signal and can be easily captured, interpreted and manipulated with standard off-the-shelf tapping equipment. Private and public networks today do not incorporate methods for detecting optical taps in real-time, offering an intruder a relatively safe data extraction proposition. As fiber optic systems transmit large volumes of data as light within an optical fiber, such methods are thus a preferred lowrisk method of intelligence gathering, reaping access to large amounts of information. From an eavesdropping and espionage point-of-view the benefits are

Today we live in a society where corporate espionage has become an international sport. As communications using fiber optics become increasingly ubiquitous, so too does the potential for the illegal tapping and

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What an intruder sees

Communication Optical Receiver

Optical tapping "devices allow the extraction of all voice and data communications in the fiber plant with little or no chance of detection.

This is achieved because the light within the cable contains all the information in the transmitted signal and can be easily captured, interpreted and manipulated with standard off-theshelf tapping equipment."

Dkt. No. 100-3; Ex. M (Oyster Optics White Paper) at 1



Examples of Optical Taps

Case 2:16-cv-01302-JRG Document 165-4 Filed 10/03/17 Page 5 of 21 PageID #: 2122

- Splice
- · Splitter or Coupler (Variable)
- Non-touching methods (passive and active)

SPLICE: The simplest method of tapping is by splicing the optical fiber briefly and inserting equipment to allow for the signal to transit to the end party while also being intercepted by the intruder. Optical splices do provide a momentary lapse of data while the fiber is not operational. Carriers do not, however, have the real-time ability to locate fiber breaks and must then usually roll-out trucks, technicians and insert additional external equipment. Thus, if downtime is short, many operators will attribute the disturbance to a network glitch and allow data transit to continue, unaware that a tap has been placed. Most off-the-shelf tapping equipment today, however, does not interrupt the signal and thus the splicing method is not preferred.

SPLITTERS AND COUPLERS (VARIABLE): Such methods allow the tapping of an optical fiber without actually breaking the fiber or disrupting the data flow. One of the lesser-known properties of optical fibers is that light is easily lost from both the jacket and the cladding of the fiber, particularly if the fiber is bent, or clamped, in such a way that micro-bends or ripples are formed in its surface. Perhaps the simplest example of such phenomena is that one is able to see the light in an optical fiber if one holds an optical fiber in one's hands. Just as simply as one sees the light (as one's eyes are after all biological optical detectors), so does the equipment designed to interpret it. In reality, all that is required to extract all of the information traveling through an optical fiber is to introduce a slight bend into the fiber, or clamp onto it at any point along its length, and photons of light will leak into the receiver of the intruder.

Diagram 2: Illustrated below are two simple taps that allow for the bleeding of light from the optical fiber.

Optical this ace

Low Light <1%

Action Fiber Optic Cable

Cladding

Jacket

2(a)

Challeng

Jacket

Optical Div ace

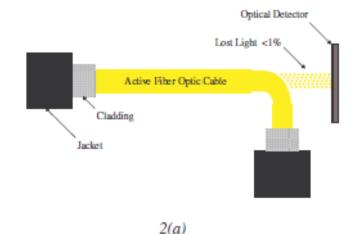
2(b)

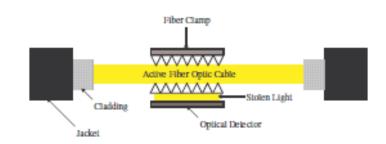
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In fact, many optical fiber test instruments are designed specifically to take advantage of this fact. For example, below is a commonly available Optical Fiber Identifier that is used to determine the direction of an optical signal, without the need to remove the jacket. Other passive, non-intrusive tapping devices are also shown.

<u>Diagram 2:</u> Illustrated below are two simple taps that allow for the bleeding of light from the optical fiber.





2(b)

There are three primary methods for optical taps:

- 1) Splice (data loss)
- Macro-bend, micro-bend, variable couplers (light loss)
- 3) Non-touching methods based on scattering (passive active)

Ex. M at 3-4

All of these tapping devices draw some of the light's power from the fiber optic line.

Dkt. No. 100-3; Ex. M (Oyster Optics White Paper)



Case 4:17-cv-05920-JS

Why did the problem of undetectable tapping exist and how do the asserted patents claim to have solved the problem?



The Patentee Recognized a Need for Secure Optical Data Transfer that **Required Tapping Detection Capabilities**

US-8,913,898.B2

FIBER OPTIC TELECOMMUNICATIONS CARD WITH SECURITY DETECTION.

CROSS OF LESS MORE THE RELAXEDA

The present patent application is a continuation of U.S. putent application Ser Sec. 12:598:195. Biol Nov. 4, 2005. which is a continuation of U.S. palent application Ser. No. 10/1986/d/\$ (how 90% that No. To 2003/25); 66x3 July A, 2003. 10 which claims priority to U.S. Provisional Paratt Application Net No. 10/303-932, tiled Jul. 9, 2001; the entirety of which use all bieneby interspetrated by indirectors.

BACKURGENEOUS THE INVENTION

tions and more porticularly to transmitter and overview for iday spily agiworks

la current liber optic métoroles un electronic data stream i fed to an optical tibes multiplescor, which is also called "a box? in the industry, Each multiplenor man on a specific transmissionistandard, for example, SOSEY A laser and on 5 explinite modelnion circuit for the laser hydridly are focused on a cord, which his into the box. The laser implicable morbilities exploitly pulses or others the foses current to create sen sempletude-encodetated replical signal poperaginal series the electionale shale staction. The fatige temptifieds modulation and I favor since delates a immunister for emergining the optical riginal over on opinical liber. A receiver tie the amplitude: mobilized opinical signals of the opiniol skins topically includes a photodistic teconwerl the optical oliquels back into the electronic data rangem. Note the terrominist and the fit receiver repetitly are freshed on the backplane of a single card, which is applicable thought a component tief.

The earl hypically abot contains uncomedite be readings at least one optical liber. For example a display 192' connectors. district, endisplayed employ. By opening the \$44.00 or The commence aroundly are found on a because of the in wardingth different families workingth and for distriction gard, the florestate being nomenders to the buckplane.

The rending of the amptitude modulated optical data sign mile, undang the photosphesial one the send instingiphiling and, the refecults goes effect product as electric computed the phono-dissip or stay do not. As a result, or computed electronic data or manifold the record of the between the PDM and the record streets of superior ones is separated.

and for the economy of the optical data on the starf that is: relatively simple. All that is required in a publical circuit for their posints three inflations of the reference charitans. pulsing the later as a direct function of the input date under to leak. If the sprint liber system has changed relative to the photodisdo for the receiver.

Existing supplied enabled by tens browth deadour. tage than the lither can be emity tapped and one in secure.

15.5. Bit. No. 5,555,696 purposes to disclose a secure fiber.

repie communications system based on the genericles of it. 15 dependation of the fiber system may greatly an abandopsis pany interferometer A data transmitter is a plane modula: her for undulating transfer propagating high featurined by a receiver round a trop. The receiver includes of the thorough with the approximant location of the deproduction becompleted for splitting hight lever the hight source into modulated light beam, and as extent director II. S. Pat. Soc. . . . display model on an electrical organization on the earth to f.223/67 discribes a similar Sagrac Interference based. displayin sharm operator, or involved by the investible. remove opening over a single opened liber.

The Suprac-interferometer based systems described in these potential are the disadvantage that they require the high. In Oher upon length request for rependent that has computable to staved over a loop, whether dock and light in a single litter with standard opical similarlesconogeration. For example, issuor over a long tragget tragget there A convertile, enterwise left. An experient substances, on early to your function? If demonstrate, the

budget for the single liber must be skydded, reducing the date carrying capacity for a single filter, or also a braped liber with equations and expensive extra length of at least revice that or is simple fiber, must be laid between the brassmitter and the receiver. Monorcer, the receiver contains the light source, as approach to the current installed have where the transminer him the light source

The Sugner-interferometer-based avoletis-thus are experrive to build and operate, and do not work particularly well. with relining emispherorace and Komato

Several companies currently gravide (NTDR) griscal time domain relactionstern's which can monitor an obtain the and determine if the preference of and houseon of a break in the Viber: Spels composino (nelsilo Wrait) Formannication Fix 23 with the NPW Series Manufactive and Hitch monades from Telegraphic Companies and the

These delection fermions are expressive and used be The present invention relates personally to reference uniques applied to the library rept. How the how

M.S. Pur, No., 5-230-728 shortness devaluate of DEDRI scale 20 nology and it harsby incorporated by reference harsin.

STANDARD OF THE PERSONS INCOME.

As about of the present investige in to provide a transcolour cord, he preveding severy surfeed data transmission are option from Austine alternation additional edges of the process beweather in to provide the explorement of exhaling search with a supposition send permitting HEFFE and appear detection constitutes.

mining this over a time option labor and receiving thes over a second optical liber, the card loving a measurer fertimes enitting, status veyer, they first expelical inflore and or receiver it connected optically in the second-optical filter optimize from the receiver. Preferable, the OFERR agreement in a war already that is different than the wavelength and for this transmit have and in connected in this replant income not removed and mission, the HHDR may be allowed to continuously opening well-cut discreption of the data encha-

Photianthly, or except first distorted is also give likely or the

The OHM prelentile immentionality are unhelded pre-The electronics for the amplitude randomium of the faser - censor within the box. The processor units are the OFDM compart data to obviorming it the absorbers data of the agrees reference (FEDM characteristic: then is deprochases of the replical titure system, which may indicate a liber from beautiful. Ober up, can be legged along the protected the degradation power reliable traffic location of the self-life. The indication of good, a hight on the cuttade within her, on a commencenting plants. Microslophy the CHTM colput may be connected to and he produced in the network operations overher.

The stansoring card of the present invention preferably the

SUMMARY OF THE PRESENT INVENTION

An object of the present invention is to provide a transceiver card for providing secure optical data transmission over optical fiber. Another alternate or additional object of the present invention is to provide for replacement of existing cards with a transceiver card permitting ODTR and tapping detection capabilites.

'898 patent at 2:24-29

- Networks were not secure against tappers
- Need for ability to detect when a fiber optic line was tapped

Case 4:17-cv-05920-JSW Document 112-1 Filed 07/08/20 Page 20 of 31 More Secure Than "Amplitude-Based Cards" By Detecting A "Drop or Increase In the **Energy Level" -- Required Constant Energy at Receiver**

US 8,913,898 B2

OTDR and energy level detector must have a measurement Avannic range that coveres proper regulation over the spanlength limits of the transceiver cord. By specifying liber span length ranges for the OFDR and energy Advector enhance ransceiver, the cost of implementation of the EPIDR and mergy level detector can be optimized with spon length than providing an optimized cost of implementation benefit to the

The present invention thus permits a cord-based atmostistion resistant incomporating an energy level detector for optical. tap detection, which can provide for more secure data transthis gath slow band-daillyon quising milt win ing, the OTDR and energy level desector parts along with the optical transmitter and receiver components can fit all on one card compatible with most existing box dimensions.

The insumitier light season prefeably is a lose, for example a semiconfactor laser operating at a 1550 nm, or 30 bours are well known in the art. Card I of the present invesother, wavelength.

Professible, the energy level detector provided on the cord by measuring light energy in a filter is connected electronicolly to an alarm, so that when a deep or increase in the energy. level in delected, which may indicate a top, the cost may 2 how 2. pero ido an olaren signal. En example an electronic signal sont Constructed international contents in health of the colorest of the person for the optical energy level, a light on the outside of the box or a such emitting alarm. Hoperating notes the notical resource sion method implemented, a successful tap may be placed by adding light to the system through the topping device. Implenations of the single liber Sugnac transmission method Ameribad in U.S. Pol. No. 5,223,967 may be sunceptible to such a topping method unless an energy level detector that ... monitors for an increase or decrease in the optical signal level is included as part of the design.

The card includes an ortical tiber interface for at least one liber, and preferably for two libers. The interface may be a depley St. consector, for example.

The eard prefembly is a replacement part for an existing

The present invention also provides a method for providing a continually-operating or, perforably, a communical opera-

replacing the inneceiver card with the early of the present

The present invention also provides a method for manufacrating an optical transceiver card for transmitting data over at 10 effectively, since the amplitude of the optical signal is conleast one data transmitting optical liber, the eard laving a resentiter and a receiver, the method comprising the steps

placing a transmitter on a related circuit board. placing a receiver on a printed circuit board; and placing an OTDR on the printed circuit board.

heleably, an energy level detector is also placed on the printed einesit frand, and a light in connected to a faceplate connected to the printed circuit board, the light indicated a

BRIDE DESCRIPTION OF THE BRAWINGS

FIG. I shows schematically a cord of the present invention board in an existing telecommunications from such as a

FKi. 2 shows a block diagram of the transcriver of the

F1G. X shows a description of an analog energy level detectox of the present impration

DETAILED DESCRIPTION

example a multiplexor, retitled with a card. I of the present invention. How 2 has no electronic data input 3 and output 4. which connect to a motherboard \$ of the box 2. Motherboard advances in somiconductor and optical component puckup- 11. S includes a bus 4 for connecting existing amplitude-based cards to the motherboard S, and connects the input 3 and curput & through for example, data conversion circulars, to the bus 6. The type of bus 6 is dependent upon the box tion includes electrical connections # to fit into bus #.

Card Enlso includes a theopline 9 and a backplane T, which preferably is a grinted vincuit bound. Faceplate 9 may be perpendicular to backplace 7 and be thesh with a firest side of

diplex SC connector, for connecting to an output fiber \$10. and an input liber EH. Alternately, a single liber for inputting and outpotting singula could be provided.

F1G. 2 shows the cord 3 of the present invention in most Artol. A transmitter 10 transmits signals over optical fiber. 110. Transminer 10 includes a single laser 12, for example a semiconductor laser emitting a narrow band of light at approximately 1550 nm, or at other novelengths. Eight emitand from laser 12 passes through a mechalister 14, for example an amplitude or plane includator, dispuly send to or part of the same package as laser 12. The light may be depolarized by a depolarizer 14. An electronic controller 18. preferable manufactured directed on the printed circuit board of back ii) plong 7 (ESG, 3), controls modulator 36 and may provide power to hour 12 liqui data 18 is fad to the controller 18. which then controls modulator 16 to modulate the light from Soor \$2 as a function of the input data \$9.

The trunsceiver of the present invention preferably or tion OTTM within an existing box including the steps of:
the in a phase-excluded mode, though conventional amplitensoring on existing transcrives cost, and
tode-modulated transmitters and receivers, including those using return-source type signals, for example, may also be used. The phase modelated signals have the advantage than breach desection by the energy level desector work more stand and those a cheep in the optical signal Revel is answer analy-

Optical signals are received at connector 800 from the

each functioning as a splitter. Splitter EEE in preferably a way chaugh division multiplexed coupler/spliner to allow the OFDR 132 to operate at one optical wavelength, for example 1670 nm, while the transmitted data stream 19 and received large is energy in the detector or degradation of the optical to data stream 34 are carried on a different wavelength, for grample 1550 nm. This functionality allows the OTDE 132 on immuniver card I is be commanded to continuously approare without interruption or corruption of the received data stream 34. Spliner 434 splits off the wavelength of light A preferred embediment of the present invention is stapplicable to the OTTM into ther 133, which has an input to described below by reference in the following drawings in OTTM 132. Splitter 31 then uplate off a previous of the remaining other light, directing part of the optical energy to on

The present invention thus permits a card-based transmission system incorporating an energy level detector for optical tap detection, which can provide for more secure data transmission than existing amplitude-based cards along with breach localization services from the OTDR. Because of

'898 patent at 3:10-14;

Preferably, the energy level detector provided on the card for measuring light energy in a fiber is connected electronically to an alarm, so that when a drop or increase in the energy level is detected, which may indicate a tap, the card may 25 provide an alarm signal, for example an electronic signal sent to a network operations center to indicate a drop or increase in the optical energy level, a light on the outside of the box or a sound-emitting alarm. Depending upon the optical transmis-

'898 patent at 3:22-29;

'898 patent at 3:10-14; 3:22-29

What was Oyster's preferred method for constant receiver energy?



Advantage of Phase-Modulated Signals Per Patent Disclosure

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OTDR and energy level detector must have a measurement dynamic range that ensures peoper operation over the spanlength limits of the transceiver card. By specifying liber spanlength ranges for the 17113R and energy detector enhanced. transperver, the cost of implementation of the OHDR and 5 energy level detector can be optimized with span length than providing an optimized cost of implementation benefit to the

The process assuming that permits a gard-based transmit sion system may up making an energy level detector for optical the detection, which can enough for more necuse distribute. mission than existing amplitude/hased cards slong with breach localization services from the CITIR. Persone of all suggestive and control processes and companies packing in a finishest back for connecting centing, amplitude disself ing, the CFFDB and energy level detector particulous, with the optical transmitter, and receiver compensate and thall on one cord comparishing with most existing bow-dimensions.

The innomiter light source preferably is a laser, for other, wavelength.

Preferably, the energy level detector percohal on the conf. for measuring light energy in a fiber is extracted electronically to an alarm, we that when a drop or increase in the energy. level is detected, which may indicate a top, the cord may 21 for 2. provide an alarmy agnal. for example an electronic signal ann to a network operations center to indicate adrops or increase in: the optical energy level; a high out he into also it the horse in a sound-conting of our, Depending upon the optical franciscosion method implemented a successful top may be placed to adding light to the system through the topping device: Implementations of the single Mor Nagata transmission method idencethed in U.S. Plat. No. 5223.567 may be susceptible to such a tapping method andox an energy havel detect within monitor-for an increase've decrease'nt the optical signal level as inschalated as port of the devices

The total includes an optical liber interlate for at boost trac-Abor, and preferably for two fibers. The interface more he is daplet SC attended for example.

The cord preferribly is a replacement part for survivising optical multiplicate transcriver trans-

The prevent assume souther preventes a method frepreseding. a continued by pendage or preferably a communifel openition DEDE within on executing to wanchalong the steps, of

nemoving in existing transcener and, and replacing the immediate card with the cord of the present

The present invention also provides a method for manufacforms as optical frameworks and for formed ling date or our feast one day transmitting opical liber, the cart faving a attenuatives and a recovery the molecul comprising the steps.

placing a transminer and printed circuit brank. placing is recover on a printed circuit bound, and placing on OF DM on the printed discuss board.

Preferably arranegy level detector is after phasel on the printed curves found and a tight is econocied to a taceptine commerced to the printed circuit board, the light indicated a change in energy at the detector or deproduced within optical. *

BRIEF DESCRIPTION OF THIS DICAWINGS.

described below by reference to the following drawings, in

ERG. Exhows schematically areard of the present invention Exceed in an existing achievament carbon few, such as a

UK. 2 shows a Block shapon of the transceiver of the

FBG. Vishows a description of an aming energy level ideac for of the present intention.

DETECTED DESCRIPTION

636. I shows an existing telecommunications box 2, for arcomple a multipleace, whiteal with a could Lot the present invention. Bex 2 has an electronic data input 3 and output 4. which counts to a motherfound Sof the box 2. Motherboard cards to the upstherward St and coupees the lapat St and compil 4. through for example, date general managing to the bas 6. The type of bus 6 is dependent upon the box mondactorer and different types offlower, methods and example is remisconductor four operating of a 1550 aim, or 31 faugu are well known in the art 5 and 1 of the present invession includes electrical connections \$ or lit into bur \$.

First Pater on today a foreplate Family backplane Facility preferably is a printed circuit found. Exception 9 may be perpendicular to for kplane Tambbe Birdt with a front side of

Fadeplate 9 may have it liber termester 100, such in it daplex SC connector, Conconnecting teranoutput über 148 and an input firer H4. Alternately, a single liber for input ing and intrinting signal could be previated

(16.) 2 shows the eard 4 of the present in entire in more aktur). A transmitter IR transmit organic over optical liber \$100. Learnmetter 100 includes arounder laser \$2, for example a semicetificate later century a toron band of light at approximately 1550 and or at other was clengths. Fighteenit is sed from laser (2 passes shrough a modalator 10, for example are tomer trailer on Abasic transfer little and departies are trained as a few analysis the same package as laser 12. The light may be depolarized by a depolarizer 14. An electronic areas for 18. preferably manufactured directed entitle printed areconfrond of thatis 4) plane T (FIG. 1), controls modulates 16 and may provide power to fours 12 (agent data 49 in ted north-controller 48. which then eventude modulator lives mediable the fight from from 12 in a femalese of the input class Ph-

The transcence of the present as enton prehendly oper 33. Steven & photocomodulated mode through convenional amplitrade-modulated transmitters and excenses, including those using return to exercity to signals, for example, more also be med. The plane misdalated regulatelizate the othic advantage that female detection by the energy level detector work many ellisticulty since the emplitude of the optical algors in som stant and thus a drop in the optical signal level is more usedly

Optical planels are received at connector 100 from fiber

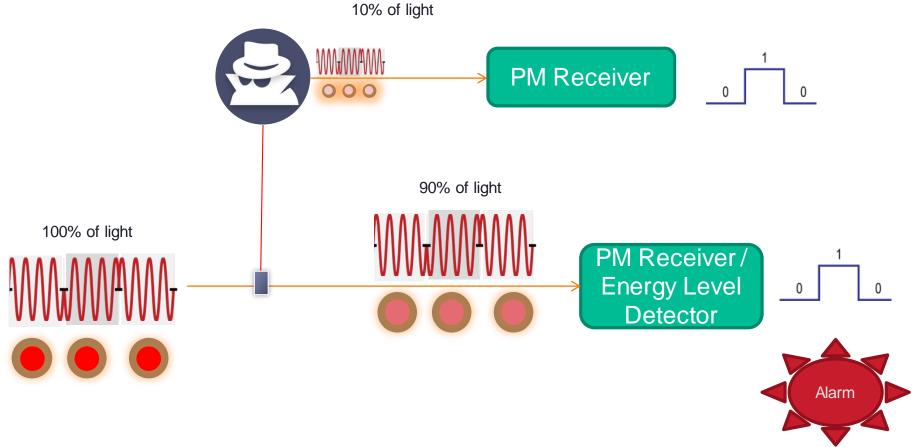
11 Beserver II includes two coupler oplines: II and IIIeach timesioning up a stringe. Splinger OH is preferably a was along the district a multiple and complete up later to of the che 000000 132 to spende at our optical wavelength, for example (A. D. ann. while the immenisted data stream 19 and received show revenue 24 race parties from a different wavelength. To example 1550 cm. This thresional evoltows the OFDH 132 resinances and the becommendal superimently open are windown internation or committee of the received that stream M Spliner IM spire off the wavelength of light A preferred embediator of the present involves to 11 applicable to the OHOP interface 130, which have input to Of Did 131. Spliner 34 item splits off a purchased the remaining office fight, showing part of the optical energy to on used. The phase-modulated signals have the advantage that breach detection by the energy level detector work more effectively, since the amplitude of the optical signal is constant and thus a drop in the optical signal level is more easily detected.

'898 patent at 4:48-52

- The patent explains that the amplitude of a phase modulated signal is constant.
- The patent explains that the **constant amplitude** of the received phase modulated signal makes it easier to detect changes in amplitude than detecting changes in an amplitude modulated signal.



Solution As Explained by The Patent: Detect Tapping by Observing Changes in The Energy Level of a Phase Modulated (PM) Signal Using An Energy Level Detector



The phase-modulated signals have the advantage that breach detection by the energy level detector work more effectively, since the amplitude of the optical signal is constant and thus a drop in the optical signal level is more easily detected. 4:43-47

With Oyster's patented technology an alarm occurs when the change in the received light energy exceeds a threshold.

If A Drop Was Detected, Then An Alert Was Provided

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5

energy level or application Ω , and present the recolorising light to an optical receiver Ω . Optical receiver Ω converts the optical signal from episcal to classe up from a section the electronic state stream. As a presenting to the optical recollistion technique amplicate.

PIDE 12 has a control circuit LM and a but 135 which allows the devest to the controlled by a processor. The OTDE that can mention the little 1811 and growthe information through two 135 to a processor for adamming the features of

Total Attending in high cases in its inter (1) deter higherous contests of a decision in spines II. Of the reliable between the state of the spines II. Of the reliable beginning with reliable to the contest of the officer of II models as decision of the obligation of the performance of the obligation of the obligation of the performance of the obligation of the obligation of the performance of the obligation of the obligation of the II. Due by conting in their recording the public of the obligation of the III. On providing the obligation of the their propertion of the date of the obligation of the obligation of the obligation of the control the dates the obligation of the obligation of the obligation of the value of the III. On the case of the obligation of the obligation of the control the dates the obligation from the energy detection electric or processors within III. Schole may be shared with the OIDR counted care III.

Fith 3 dense this image level shapine 33 on the program invention in more detail. The energy level decision 33 described by Vis. 3 represents a problemal analog implementation, with other implementation executs possible, the boundary the objuid anxiety entitles an associated and implementation with a state of the control of the contro

A photodelector or other optical to electrical extracricus device 153 measures the optical signal coupled to its input by scopler-splitter 31. The output of photodetecter 132 is not electrical voltage whose fevel conductorable opical power. of the input to the photodetector 450 bosed upon the photodetector 150 transfer optical to electrical conversion transfer. function. Depending upon the electrical bandwidth of photodetector \$55 and the optical signal formar present at the input to photosistener 18.5, the statement agend may be bilated by colore passether I false preside an average surfage fewer which is represents the average optical power measured by phistodenector 153. After libering the signal, the electrical signal may be conditioned and scaled by either a legicithmic to linear amplified 191. Scaling the data may be successful to ensure their entersys level dielections can be neade without recitions made. degradation over the span length range required for the cirsent. The shake of section type is diesen primarily based. upon the optical to electrical convenien manufes baseton of the photodetector and the tunato of espected artical proverlevels as the plantadescence Magua based upon span length. ranges. Generally, the involve function of someoniheter. phonodetection devices is exponential with respect to optical to decircal conservant for such commonate the cosmile of as exponential physiological with a logarithmic surplinic offices the aids untigge of proventing a real functor framedor familient. firms epideal proversi the lignifie the epiciodelection is college. at the longithmic appelities. Thus, a diebally resenounable, descrion threshold cambo developed which afterests some repolition per fet reportilen of the man length of the device.

The electrical riginal other beings water by the fattern or or logariflanci amplified 15% to compare the reference subaper bosoneromeromemorates, he shown in 15% A comparing 15% of transfer from a two left at entert white the subaper from the Experiment or biase, comparing the temperature of the experiment or the control of the reference of tigge entertified by the digital to make 15% A scorement 15% comparing the material from the form the set from a factor of the factor of the factor of the factor of the control from the

Jogavitmic or Jimor simplifyin FME talls; balley, the reference voltage exist histed by the singulation analog converter 159. The outrof of DR gate 160 will importion from low to high when either the entent of component 154 or component (57 tranamong from tive to high Firethe example of \$550 A an alarm नाम () कारों के दर्बाल में कि पीट मांगूक जे दें हैं हुआर के हैं कि हैं To indicate an altern state, the OR pare output may be good in and the classes in a seer 142, a visual about visual glat or light. printing diede (FFF) 184 or may indicate an alumn state to the processor via the energy level detector another 233 and processor has \$38. The whereave volence and shide of high five A converters 150 and 150 may be programmable alreagh a ingital processor or state muchine via a shuital bus, \$15 and an energy level ideoctor mertice caroin 233, that as more introduction CAA pand 664 may be availableful as provide referrace levels for compatives to determine our or, more alarmstates. This the circuit of FK: I may be configured in minifor in real time the optical power at the receiver. Hit is received Night any was little bight an indicate to personal operated sign. tamper or other degradation of the optical signal.

A digital sirvail continuant for 50. 3 may be developed, Autorg to digital converted of the Experiment of the Experiment

The compensant since unit types will depend upon the type obtransmission desired. For example PP, Dearly may vary in size and certain compensant types from MC-PW cards.

While the earth may be placed in new brace, the present invariable permits, for the removal of existing spitial transmission, and is to be could emplaced by the inflament energing code. The theoryte discovered is the few 2 is simply operated and the complete on delition braced want to be completed in delition braced with the means of The card of a material must the bust of and the lithern the control of the present of the bust of and the lithern the control of the bust of and the lithern the control of the present of the bust of

The card that the present arrests on may thus provide examing braces with continued breach the attention and defection occurs from more and achieves of the control transmission made controllers.

Moreover, a separate OTOR which is space consuming and not be provided.

While the energy-level assector must be at the receiver side, the DITO' also would be beauted on the transmittee only.

When its channel in

 A transceper catalog a relocationation has for transmitting data over a few optical liber and reacoust data over a second optical transplantation conformation.

- 6 framewitter has my of them, of metabolics, and a controller configuration receive imput date and controller needlates to entertain a limit optical upon his orientation of the input flore.
- a liber seperat (pheally connected to the transmines and companies) opicially counce the land-opicial trace to the transcence and
- a more or configured to receive a second special again fearethe second wheat fiber and a Convertile second opened signifector or their
- ther input optically connected to the receiver and configured to optically connect the second optical liber to the transcence card, and

Detector 33 monitors the light energy in the fiber 111 via the light energy coupled to the detector by splitter 31. If the amplitude drops during monitoring, which may indicate a tap, the detector 33 provides an alert and can, for example, send and electronic signal to the processor via bus 135 to indicate 15 a drop or increase in the optical energy level, sound an alarm or alert network maintenance personnel, for example through an LED 133 or by sending an alarm message using transmitter 10. Another LED 134 can provide an indication of proper

'898 patent at 5:11-19

• If the received signal amplitude (i.e., energy) drops during monitoring, which may indicate a tap, the detector provides an alert.

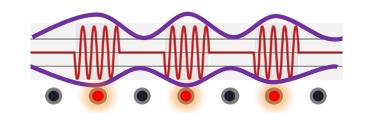


Oyster's Solution: Monitor Changes in Light Energy (Intensity / Brightness)

Signal envelope (~ energy / amplitude)

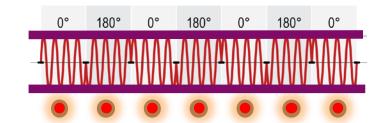
Modulated Optical Signal

AMPLITUDE MODULATED OPTICAL SIGNAL



The intensity (brightness) of an amplitude modulated signal is *not constant*

PHASE MODULATED OPTICAL SIGNAL



The intensity (brightness) of an ideal phase modulated signal is *constant*

used. The phase-modulated signals have the advantage that breach detection by the energy level detector work more effectively, since the amplitude of the optical signal is constant and thus a drop in the optical signal level is more easily detected.



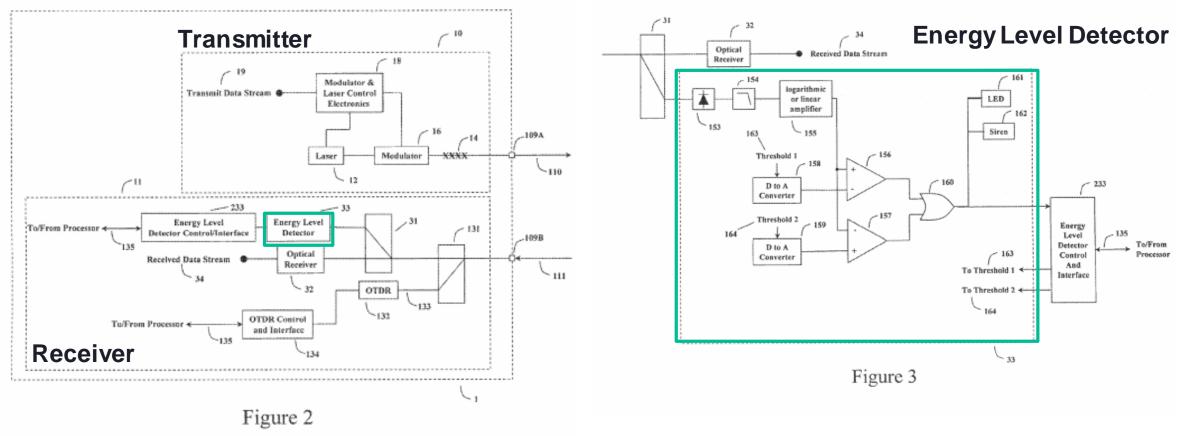
Case 4:17-cv-05920-JS

HOW DOES THE ENERGY LEVEL
DETECTOR
DISCLOSED IN THE ASSERTED PATENTS
WORK?



Energy Level Detector # 33 Document 112-1 Filed 07/08/20 Page 26 of 31

Transceiver



In the energy level detector, the output of photodetector 153 is an electrical voltage that is correlated with the optical power at the input to the photodetector.

The electrical signal, may be averaged, and is compared to reference voltages that correspond to upper and lower thresholds that cannot be crossed without setting off an alarm.

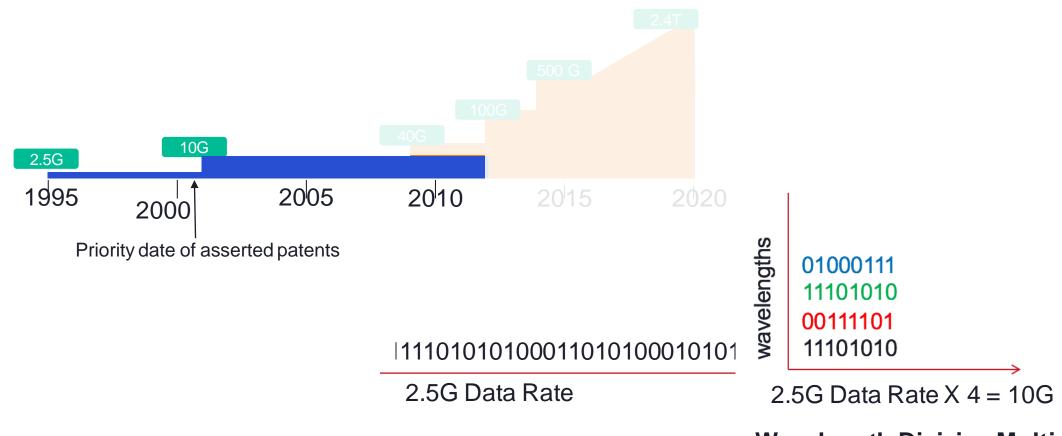
Case 4:17-cv-05920-JS

Major Technology Progress Over The Last 20 Years Since Oyster's Patents Were Filed.

Wavelength Division Multiplexing Coherent Optics: Gb/s → Tb/s



Even with Continuous Improvements (WDM) Direct Detection Systems Start to Lose Relevance In Early 2010's

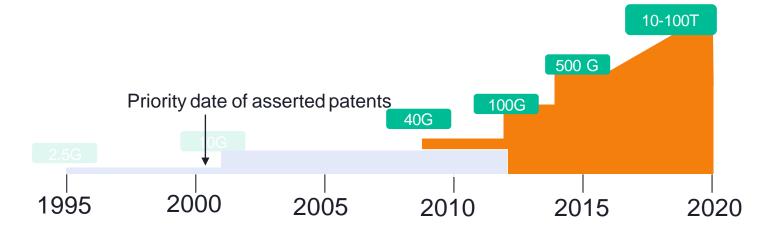


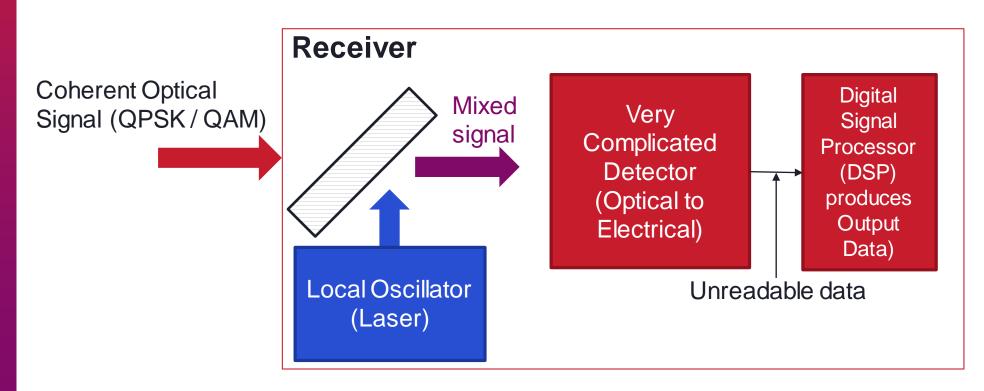
Wavelength Division Multiplexing (WDM)

G denotes gigabits (billion) per second

Coherent Optical Communications: Novel Technology that Took Over a Decade to Design

- Signal phase, amplitude, and polarization modulated.
- Receiver mixes the optical signal with a specially tuned laser and powerful DSP
- Integrate coherent system with WDM
- Enables Terabit/sec communications





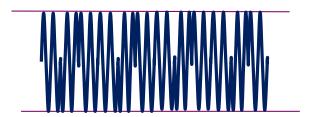
01111010101000110101000 11010101000110101000101 11111010101000110101010001

Output data

Energy Level Detection And Signal Type

Envelope

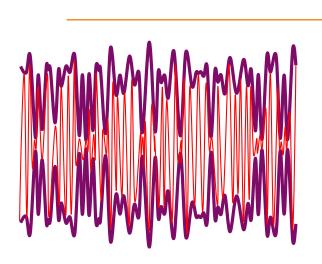
Phase Modulated Signal



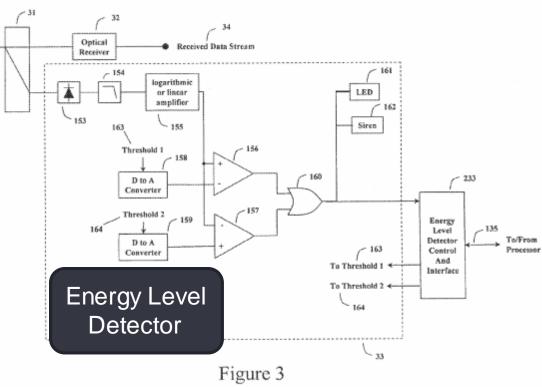
Oyster's Energy Level Is Designed for Constant Envelope Phase Modulation with Direct Detection Receivers.

Envelope

Coherent Optical Signal



Oyster's Energy Level Detector And Receiver Are Not Designed For Extremely Complex Coherent Signals with Peaky, Variable envelopes.



Oyster's Described Advantage of Patented Phase Woodulated Signals



Securing Fiber Optic Communications against Optical Tapping Methods

Optical tapping devices placed in public and private optical networks today, allow unfertered access to all communications and information standing any fiber segment. Available legally and inexpensively from numerous manufacturers worldwide, optical taps are standard network maintenance equipment that are in use daily. When used refatiously, optical taps provide an excellent method of interopping voice and data communications with virtually no chance of lbeing detected. Intruders are therefore rewarded with a bounty of relevant information while subject to a very low risk of being caught. Optical network equipment manufacturers do not currently incorporate adequate protection and detection technologies in their platforms to monitor such networks and therefore cannot prevent the extraction of sensitive data and communications. Government networks while assuredly more secure, are also vulnerable to octian in pes of advanced passive and active tapping methods. This background paper serves to provide an overview of the vulnerabilities of today's modern optical networks, describe methods of addressing such issues; and introduce Oysier-Optical palented optical security, monitoring, infrasion desection and breach localization solutions.

INTRODUCTION

Fiber optic telecommunications waters make up the backbone of all modern communications networks. Whether voice, data, video, far, wireless, email, TV or otherwise, over 180 million miles of fiber optic cables worldwide transport the ever-increasing majority of our diverse information and communications. Modern economies and societies nely on the availability, confidentiality and integrity of critical fiber optic network infrastructures to function properly and efficiently.

With the initial introduction of fiber optic relecommunications systems came the belief that fiber based transmissions are inherently secure. It has since been proven that not only are lither, optic systems simple to tapbase in many respects they are simpler to taphan their copper-based predecessors. Furthermore, tapped optical networks dividige much greater pertine no information in a more orderly and digitized manner. In fact, many fiber optic taps are standard network maintenance equipment used daily, by carriers workshold. Deel Illicity.

however, such sherious allow the extraction of all voice and data communications in the fiber plant with little or no chance of describes.

This is achieved because the light within the cable contains all the information in the transmitted signal and can be easily captured, interpreted and manipulated with standard off-the-shelf tapping equipment. Private and public networks today do not incorporate methods for desecting optical taps in real-time, offering an intruder a relatively safe data extraction proposition. As fiber optic systems transmit large volumes of data as light within an optical fiber, such methods are thus a preferred lowrisk method of intelligence gatheringreaping access to large amounts of information. From an eavesdropping and espionage point-of-view the benefits are

Today, we live in a society where corporate espionage has become an international sport. As communications using fiber optics become increasingly abiquitous so too does the potential for the illegal appring and

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Even though the input and output electronic data streams to the multiplexors and switches remain the same, the transmitting the data is in a patented secure phase modulated format different from any commercially available products. Because of the format of the light, Oyster Optics' technologies are therefore able to provide an extremely precise and sensitive tap detection system, which would not function with equipment amplitude or intensity modulated Furthermore. Ovster Optical Time Domain Reflectometer ("OTDR") to instantaneously locate the exact source of an intrusion or maintenance event and determine its origins, such as an actual tap, a physical line break, or even simple fiber degradation.